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AN ADVANCE ALGORITHM FOR PRECISION AGRICULTURE USING WIRELESS SENSOR NETWORK

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ABSTRACT

WSN are class of embedded, pervasive, small and inexpensive computing devices with a built in microcontroller, a transceiver and sensor nodes for monitoring environmental phenomenon. The main concern is to minimization the energy consumption of the battery operated nodes on the working Network. Another concept is to use energy harvesting nodes which proves to have better energy saving techniques than battery operating nodes. Network layer lays the highest impact on the energy efficiency based upon on the combination of routing protocols and network topology.

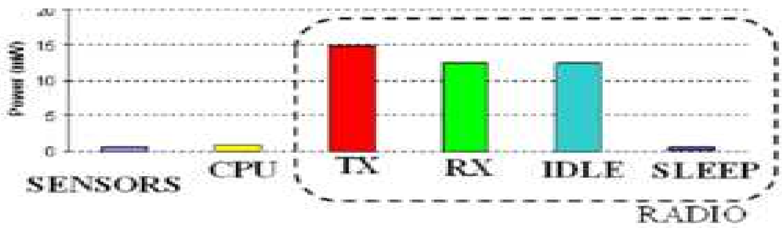
KEYWORDS: Wireless Sensors, Power Optimization, Node Management, on Demand, Cost Efficient

INTRODUCTION

A wireless sensor network is a collection of nodes “sensors” organized into a cooperative network. The nodes communicate wirelessly and often self-organize after being deployed in an ad-hoc fashion. There are many useful applications which can be used in many fields using wireless sensor network and we are using it in agriculture. Basically, the wireless sensor network is consisting of following components.

- Processor
- Memory
- Transceiver
- Power
- Sensor

Every node in the wireless sensor network has a particular goal which is to collect the data at regular intervals, then transform the data into an electrical signal and finally send the signal to the sink or the to the base node. As all the nodes doing such effective power consumption work, each one should be very power efficient to does their work without anxious results. But, Sensor nodes are battery driven and they must have a lifetime on the order of months to years and Battery replacement is not an option for networks with thousands of physically embedded nodes As in some cases, these networks may be required to operate solely on energy scavenged from the environment or based on the scenario through seismic, photovoltaic, or thermal conversion. Now let’s we consider the operations that leads to the anxious or extra consumption of energy by each sensor node.



$E_{TX} \approx E_{RX} \approx E_{IDLE} >> E_{SLEEP}$

Figure 1: Power Consumption of Node Subsystems

Figure 1 shows the power consumption of the nodes in subsystem, in the idle state the power is still consume by the node. This will directly affect our energy consumptions. The network lifetime can be maximized only by incorporating energy awareness into every stage of wireless sensor network design and operation, thus empowering the system with the ability to make dynamic tradeoffs between energy consumption, system performance, and operational fidelity.

And the basic working block structure of wireless sensor network is in the Figure 2 below.

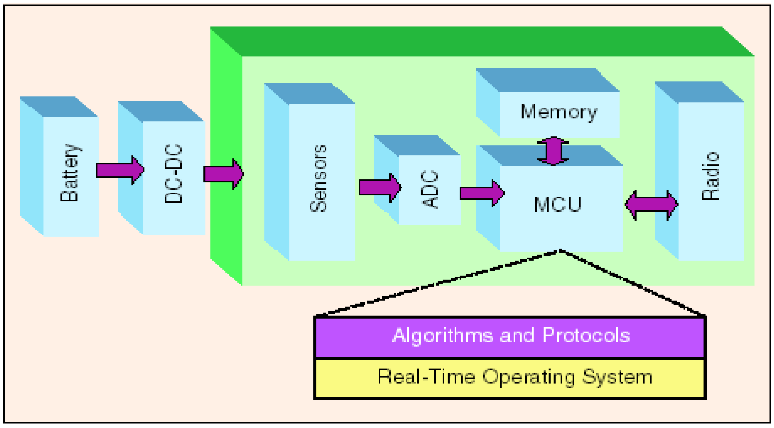


Figure 2: System Architecture of a Typical Wireless Sensor Node

The wireless sensor node is comprised of four subsystems:

- A **computing** subsystem consisting of a microprocessor or micro controller.
- A **communication** subsystem consisting of a short range radio for wireless communication.
- A **sensing** subsystem that links the node to the physical world and consists of a group of sensors and actuators.
- A **power supply** subsystem, which houses the battery and the dc-dc converter, and powers the rest of the node.

Systematic power analysis of a sensor node is important to identify power bottlenecks in the system, which can then be the target of aggressive optimization. In our methodology, The sensors are embedded in the agriculture field that makes a wireless connection with each other for the transmission or to transmit their data to main source here, more the number of sensors that are being used, more will be the power consumption. So to reduce the power consumption we are implementing some power management techniques for transmitting, receiving, for sensors and also keeping their radios low, hence decreasing the range. But for the transmission of data the sensors will use the in range sensor or the nearest node and thus a chain mechanism will be formed to pass the data to main source. This will increase the power consumption as each sensor will consume power separately. So neither we can increase the radios of sensors to increase their range nor

we can use more short range sensors because in both the cases, power consumption will increase. Also, as the number of sensors being used in passing a data increases, it will introduce time delay in the system.

So to make the system more efficient we will be implementing two co related algorithms one which will turn on the transmitter radio only when the area under the sensor requires water this will help in conserving the power and only the sensor circuit will be activated for periodic cycles, In this algorithm we will keep monitoring the average re-irrigation time and the time period of the cycles variable according to this database collection. This will help in additional battery conservation or to reach at optimal power consumption.

RELATED WORK

Lihongshenget Al [1] discussed about appropriate node management in low resource WSN is necessary to reduce the power consumption of the network and to control the energy of the networks. In this paper he proposed a use of an algorithm Ant Colony which is self organized, dynamic and adaptive which reduces the communication transmission power of a node further creating a new routing link which increase the reliability of entire network. It was proposed in year 1991 by M. Dorigo which uses the basis of pheromone used by ants in tracing a path from source to destination as it's medium. When ants look for food or finding the path pack to their nest they always choose the shortest path. While tracing the shortest path they release a chemical substance called Pheromone which is used by the later ants of same colony as a signal to follow.

Author's power management is designed as follows:

- When information from source node (ms) to destination node (md) to be sent, the destination node send an ant Ai for the search route and the ant flooding in the network carries the current node address mi and the number of hops to reach the source (ms).
- Through an intermediate node (mj) ant Ai follows the process of proliferation and hence the route between (ms) and (md) will be established. During this process an ant will lay up the concentration of pheromone on the entire route. The concentration of pheromone between each node and its adjacent node is defined by τij and the adjacent nodes as τij+1, τij+2 + ….until it arrives ms.

Hnin Yu SHWE et al [2] author discussed about whenever we use a monitoring application and in the case of intermediate node which collectively sends data to the sink leads to the buffer flow problem.

Currently available Buffer Management Schemes include –

- **Congestion Avoidance:** This will avoid the congestion of packets on network.
- **Congestion Control:** This will various policies (push out policies) to recover the packet after loss on the network.

Most redundant drop which uses spatial information from the sensing data to increase network coverage. It assumes if two nodes are very close to each other there will be duplication in the data they sense but, this information holds false in the case of environmental sensing applications in which each sensor sense a different entity.

Furthermore we use the concept of relevant and irrelevant packets –

- **Relevant Packets:** Those packets which only listen or collect information from the same layer. Example Temperature layer will only allow packets which only contain information about temperature.

- **Irrelevant Packets:** Those packets which contain information from different layers and not restricted to only one parameter.

Carlo Brandolese et al [3] outlined two basic concepts used in this approach are

- Integrated and general power management system which is transparent to end user with support for heterogeneous concurrent applications.
- A proposed model that support set points to lowest possible states (power off) with no memory consumption. The prototype used for this model is Polinode Infrastructure and the operating system used is MiosixOS. With combination of powerful hardware architecture and OS features we obtain a low power profile on the basis of
- Hibernation mechanism
- Smart sensing paradigm

In this paper, they analyzed the duty cycling and power efficiency in multitasking WSN is maintained with the use of ultra low profile ISR chips in microcontrollers which has very low booting time and the characterization in mid/high range microcontrollers with non negligible energy.

M. Lombardo et al [4] present about power management techniques used for WSN based on RAM based FGPA. WSN which performs high end computing tasks like sensor management by video cameras, image encoding, robust encryption and higher bandwidth consumption applications. Basically the use of FGPA in WSN has been avoided because of their power consumption but results showed if it's used in conjunction with hardware acceleration and some power management techniques we can obtain energy efficient solutions. Furthermore we categorize power consumption profile for FGPA Based WSN in three modes -:

- **Sleeping Mode:** In this only on necessary components will be switched on thus improving the power efficiency.
- **Configuration Mode:** In this we will reduce the reconfiguration tie which is completely independent of bit stream size.
- **Computing Mode:** In this we will save the energy consumption by moving the tasks form Software mode to Hardware mode.

To understand the concept of power management techniques we should understand the HIRE cookie platform (High Performance Reconfigurable Cookie) which is divided into 4 different PCB connected to their neighbors with vertical connector.

Cookie Layer Architecture

- **Sensor Layer:** It is a conditioning layer for both analog and digital sensors and actuators.
- **Power Supply Layer:** It can take power from a USB cable, Lithium or AA batteries or has DC to DC convertor.
- **Processing Layer (Hire Cookie):** It is the main layer where all the sensing information is processed given by sensors or radio modules. It contains Spartan 6 Xilinix FGPA and a TinyT microcontroller which helps in both processing and power management.

M. Lopez et al.[5]examine that radio transceiver is the main element of the mode which has the highest power consumption. In order to save energy we have to apply the concept of duty cycling in which the node enables the radio for periodic intervals for short period of time which later return to the idle state. Further we consider the effect of noisy channel whose interference cannot be ignored especially in the area of industrial environment. The proposed technique includes the mechanism which will minimize the effect of electromagnetic pollution and help in carrying out the normal working of radio devices in environment.

The Energy Saving Technique

In WSN, the active time period of the receiver plays an very important role. The power consumption of a node can be significantly reduced if we manage to keep radio equipment off at the time of no data transmission by the node. The energy saving concept here relies on the following system requirements:

The resources provided by IEEE 802.15.4, a defined standard for low power and low data WPAN’s (Wireless Personal Area Networks). It consist of following three bands 868, 915, 2450 MHz, each having own physical properties, but one common MAC layer. The 245GHz is the mostly used as it supports the fastest transfer rate and is also worldwide available. Furthermore the use of asynchronous centralized network also being safe and reliable, makes the non-transmission expired by NRM. That, the nodes of WSN will only transmit on request.

Jonathon Jo et al. [6] focuses on the concept of capturing the moisture content present in soil, which is fundamentally the most essential data required for precision agriculture. By the use of existing off-the-shelf hardware including (Micaz motes, MDA300CA data acquisition board and EC5 soil moisture sensor) which will make use of the embedded OS (Tiny OS 2.1.1) and Mviz, a prototype is build to collect soil moisture. The limited battery supply is the major concern of this architecture. Therefore, the uses of solar and rechargeable batteries are addressed to solve this challenging problem. The various types of sand soils with different content are used for our proposed research.

A series of experiments were performed to demonstrate the performance of implemented MDA300CA driver. A set of multiple nodes were used to collect to make a single WSN to collect soil moisture data.

- **Single Node Experiment:** In these three different types of soil is used with different levels of water saturation, namely Dry, Moist and Water-Saturated. The sole focus was given on MDA300CA driver. Firstly, use three cups to contain same type of soil. Further, dry soil is prepared by exposing it to the air for two days. For water-saturated soil, three cups of water is added in to the cup and lastly to prepare moist soil, we pour one cup of water into the cup. Then EC-5 probes are entered into all the three cups respectively. A collective reading is taken after every 15 minutes from individual cups and readings are obtained. The dry soil value came around 355, moist soil reads around 418 on the scale and water-moist soil fluctuates around 743. An interesting fact is noticed, that by increasing water in all three soils the standard deviation of readings increased

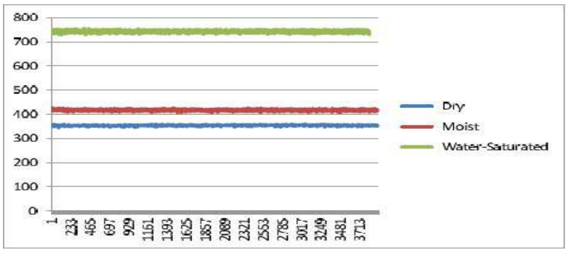


Figure 3: Reading from Three Different Types of Soil

- **Multiple Node Experiment:** From the single node experiment, a prototype of multihop WSN based on MViz application concatenated with Tiny OS 2.1.1 is prepared.

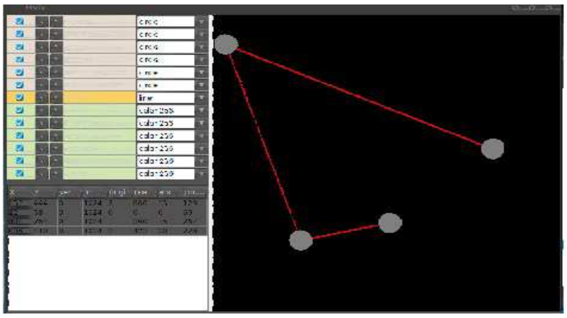


Figure 4: Screenshot of Mviz Output

Figure 4 demonstrates four nodes forming a multi-hop WSN. The top portion of left box displays the network typology. Reading from every node is shown in left box and network topology is presented in right panel. Interested readers may refer to MViz for more detailed information.

L.M. Kamarudin et al. [7] proposes a transmit power control algorithm which uses radio energy model based on varying propagation models to minimize different deployment scenarios. With the implementation of transmit power control we can increase the lifetime of network around 5.3%. However, a an efficiency of 8.7% can be achieved if the network is deployed in the presence of Weissberger's vegetation attenuation model.

For the evaluation of this algorithm, the nodes have been deployed in the simulating platform, on a 100x100 m^2 area with 10 m space between them. Initially all the nodes have been configured to maximum transmission power of 1mW and sensitivity value of -85dBm based on CC2420 transceiver device. The battery capacity of all the nodes are initially set to 250mAh, while Base Station has unlimited power supply. The network follows the star topology in which all connected nodes sends packets to BS (Base Station). Further, BS broadcast a packet to al l the connecting nodes to start the network, each node send a 100byte message every second. To avoid collisions over the network, Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA) mechanism is implemented. Furthermore, the simulations are categorized in two deployment scenarios, chain and grid. Both the scenarios contains 100 nodes, the only difference between them is spacing. The chain deployment 10 m spacing between them whereas grid mechanism has 10 m internode-spacing in regular grid, which leads to 10 different lines each having grid in center. For every single scenario 10 different seeds are used to simulate the network.

Furthermore, every scenario was evaluated using FSL propagation model, Weissberger propagation model to represent vegetation environment in the propagation path and the combination of Plane Earth with Modified Exponential Decay Weissberger propagation model (PE+MED Weisberger) to define near earth propagation environment with vegetation. The above discussion leads to the conclusion that by using a combination of different propagation models to represent a target environment, the time lifetime of a network varies significantly. It has also been shown that the application of transmit power control can approximately increase the network lifetime to 8.5% even in high signal attenuations environment.

PROPOSED WORK

In the following, we start our work by refining the problem definition, objectives and algorithms to optimize the

power consumption of a wireless sensor node. The main objective of our research is find an arrangement which will reduce the power consumption in wireless sensor networks by making the system work on demand only and by reducing the length of chain mechanism between nodes by implementing a proposed routing mechanism.

Function Focusing on Work on Demand

Since work on demand mechanism defines the working of the system only at the time when the certain set of conditions are met and keeping the system idle, rest of the time. In our research mechanism, we will turn on the transmitter radio only when the area under the sensor requires water, this will help in conserving the power, hence only the sensor circuit will be activated for periodic cycles. Furthermore we will keep monitoring the average re-irrigation time and the time period of the cycles variable will be stored in the database collection. This will help in additional battery conservation.

The work on demand mechanism is defined in an Algorithm 1 below:

Algorithm 1: Proposed Humidity Detection.

Let h = humidity and on the basis of maximum variations in humidity of soil we choose t1, t2, t3, t4 = random humidity values present in soil.

Input: Current Humidity levels present in soil.

Output: Working of the system according to evaluated levels of humidity.

Step 1: if (h <t1)

Then display the message ("Humidity level very LOW, Start Pump Now, Keep Sensors ON")

Step 2: else if (h <t2)

Then display the message ("Humidity level LOW, Start Pump in x minutes, Sensors ON, Sleep Mode for x minutes")

Step 3: elseif (h <t3)

Then display the message ("Humidity level MODERATE, Start Pump in x minutes, Sensors ON, Sleep Mode for x minutes")

Step 4: else if (h <t4)

Then display the message ("Humidity level MODERATE, No Need to Start Pump, Sensors ON, Sleep Mode for x minutes")

End

Function Focusing Proposed Routing Mechanism

In this mechanism we will perform calculations and simulations so, that farthest sensor can be deduced with having least effect on parameters like bit error rate and packet droppingrate etc and also keeping in mind that transmitter radio uses Optimal power.

Input: Data captured from environment by the nodes.

Output: Selection of the next qualifying node in the network.

Step1: The data captured by the node at the current sensor ring will be transferred to the next ring in the network.

Step2: The next ring will be selected according to the distance from the center also know as sink.

Step3: The current node will have its own range in the network.

Step4: The nodes will qualify the criteria on the following basis:-

- The next selecting node must lie in the range of current node.
- And also it must lie in the range of next ring.

Step5: From the set of all the qualifying nodes, the node having minimum distance from the sink will be considered as the best node for next hop and similarly after the next hop, the best node will become the current node.

RESULTS

In a Wireless Sensor Network, data is transferred from source to destination via a number of nodes. The transfer takes place from one node to another is referred as a hop. With increasing number of hops the corresponding nodes involved in transfer of data also increase proportionally and thus increasing the overall power consumption of the system. In our proposed algorithm we intended to decrease the number of hops involved in transfer of data from source to destination. This will in turn reduce the power consumed by reducing the number of nodes used.

The given graph (Figure 5) shows change in power consumption with respect to number of rounds. The line shown in green is the curve of power consumption versus the number of rounds for previous methods and the line in red shows the curve of power consumption versus number of rounds in our proposed algorithm.

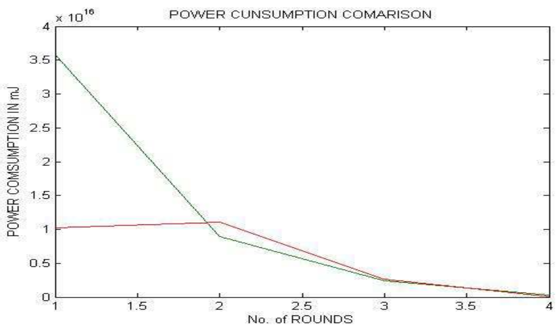


Figure 5: Power Consumption Comparison of Previous Algorithm with Proposed Algorithm

The graph is further divided into three parts by two lines N1 and N2.

The first part of the graph clearly shows that the proposed algorithm consumes less power than the previous ones (red line is below green line)

In the second part of the graph our proposed algorithm shows more power consumption than previous algorithm (red line is above green line)

In the third part of the graph both the algorithms are shown to be equally efficient.

Thus we may conclude that for the number of rounds less than N1 and greater then N2, our algorithm is more efficient than previously defined algorithms. However, in the middle region the proposed algorithm needs to be modified to reduce power consumption which is a scope for future work.

CONCLUSIONS AND FUTURE WORK

In this discussion, we proposed power management techniques, to reduce the power consumption of nodes in a wireless sensor networks by making the workflow of main processing element of the system i.e. sensors working in a dynamic arrangement. This will only work when the irrigation land needs water and also stores the periodic cycles of water supply in the database for future references. Further we devised a routing transmission algorithm, which will transfer the packets from current node to the next node having the minimum distance from the source i.e. sink which will reduce the chain mechanism between all the sensors lying in the network and increasing the battery life of sensors.

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